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Non-Contact Electrical Conductivity Measurement Technique for Molten Metals

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ABSTRACT

A non-contact technique of measuring the electrical conductivity (or resistivity) of conducting liquids while they are levitated by the High Temperature Electrostatic Levitator in a high vacuum is reported. This technique, which utilizes the principle of asynchronous induction motor, measures the relative changes in torque by applying a rotating magnetic field to the sample. Changes in electrical resistivity was related to the measured torque using the formula developed for induction motor. Validity of this technique was demonstrated using a pure aluminum sample around its melting temperature. When the measurement results are calibrated at a literature value of resistivity at the melting point, our resistivity data around the melting point can be expressed by

$r_{e,liq} = 24.19 + 1.306 \times 10^{-2} (T - T_m)$ $\mu\Omega$·cm over $T_m \sim 1160$ K,

$r_{e,solid} = 10.77 + 1.421 \times 10^{-2} (T - T_m)$ $\mu\Omega$·cm over 700 K ~ T_m,

and the thermal conductivity as determined by the Wiedemann-Franz-Lorenz relation from these resistivity data are given by

$\kappa_{liq}(T) = 94.61 + 4.41 \times 10^{-2} (T - T_m)$ $W\,m^{-1}\,K^{-1}$,

$\kappa_{solid}(T) = 211.13 - 7.57 \times 10^{-2} (T - T_m)$ $W\,m^{-1}\,K^{-1}$.

Both electrical and thermal conductivities are in close agreement with the literature, confirming the validity of the present technique.

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